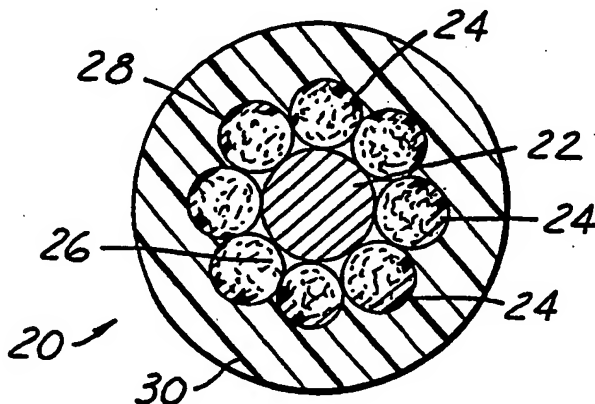




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : H01B 7/34, 13/06, 13/08	A1	(11) International Publication Number: WO 90/11605 (43) International Publication Date: 4 October 1990 (04.10.90)												
(21) International Application Number: PCT/US90/01652 (22) International Filing Date: 28 March 1990 (28.03.90) (30) Priority data: <table border="0"> <tr> <td>330,008</td> <td>29 March 1989 (29.03.89)</td> <td>US</td> </tr> <tr> <td>329,927</td> <td>29 March 1989 (29.03.89)</td> <td>US</td> </tr> <tr> <td>365,748</td> <td>13 June 1989 (13.06.89)</td> <td>US</td> </tr> <tr> <td>478,600</td> <td>12 February 1990 (12.02.90)</td> <td>US</td> </tr> </table> (71) Applicant: LESTOX, INC. [US/US]; 222 Merrill Street, Birmingham, MI 48009 (US). (72) Inventor: MUDGETT, Donald ; 10338 Oriole Drive, Coopersville, MI 49404 (US). (74) Agents: OLDS, Theodore, W. et al.; 35th Floor, 400 RenaissanceCenter, Detroit, MI 48243 (US).		330,008	29 March 1989 (29.03.89)	US	329,927	29 March 1989 (29.03.89)	US	365,748	13 June 1989 (13.06.89)	US	478,600	12 February 1990 (12.02.90)	US	(81) Designated States: AT (European patent), AU, BE (European patent), BR, CA, CH (European patent), DE (European patent), DK, DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, KP, KR, LU (European patent), NL (European patent), SE (European patent), SU. Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
330,008	29 March 1989 (29.03.89)	US												
329,927	29 March 1989 (29.03.89)	US												
365,748	13 June 1989 (13.06.89)	US												
478,600	12 February 1990 (12.02.90)	US												

(54) Title: ELECTRIC CABLE WITH IMPROVED BURN RESISTANCE FEATURE



(57) Abstract

An improved electric cable and method of making, is disclosed that results in an electric cable (20, 32) with improved burn resistant characteristics. The improved method consists of a first yarn wrapping portion (40), an impregnating section (42), a drying section (44), a coating section (46), a second drying section (48), and a coiling section for returning the wire to a reel. The method wraps a glass fiber yarn (24) about an electric wire (22) and then impregnates this yarn with a silicone compound. The impregnated yarn is dried and sent to a second coating chamber where an additional silicone compound (30) is coated about the outer periphery of the yarn. The wire goes into a second drying section and then onto the coiling section. In a second embodiment of this invention silicone tape (170) is used as a wrap around the electric wire rather than the glass fiber yarn.

DESIGNATIONS OF "DE"

Until further notice, any designation of "DE" in any international application whose international filing date is prior to October 3, 1990, shall have effect in the territory of the Federal Republic of Germany with the exception of the territory of the former German Democratic Republic.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MR	Mauritania
BE	Belgium	GA	Gabon	MW	Malawi
BF	Burkina Faso	GB	United Kingdom	NL	Netherlands
BG	Bulgaria	HU	Hungary	NO	Norway
BJ	Benin	IT	Italy	RO	Romania
BR	Brazil	JP	Japan	SD	Sudan
CA	Canada	KP	Democratic People's Republic of Korea	SE	Sweden
CF	Central African Republic	KR	Republic of Korea	SN	Senegal
CG	Congo	LI	Liechtenstein	SU	Soviet Union
CH	Switzerland	LK	Sri Lanka	TD	Chad
CM	Cameroon	LU	Luxembourg	TG	Togo
DE	Germany, Federal Republic of	MC	Monaco	US	United States of America
DK	Denmark				

-1-

ELECTRIC CABLE WITH IMPROVED BURN RESISTANCE FEATUREFIELD OF THE INVENTION

This invention in general relates to an improved electric cable that has better burn resistant characteristics than existing electric cable.

Several types of insulation for electric cable are known that each have their own individual characteristics. In general, these insulations give off toxic fumes when burned. In the case of a fire the insulation will burn and create toxic fumes that may well be more harmful to victims of the fire than the fire itself. In addition, the prior art electric cable does not survive fires very well. When an electric cable is exposed to fire, the insulation melts and the wire short circuits. This is especially true in a multi-strand cable containing several individual electric wires. This lack of survivability of the prior art electric cable can create very real problems if the cable that melts is a control wire for controlling a system such as a fire alarm, for instance.

The use of a silicone coating over a bare electric conductor is known. However, the process used to coat the wire is quite complicated and expensive. Moreover, the resulting wire is too soft and is subject to nicks and abrasions. This coating has been used with large gauge cable and not with small control cables.

It is therefore an object of the present invention to develop an improved electric cable, and a method for making same, that has improved burn resistant characteristics. More particularly, it is an object of the present invention to

-2-

disclose such a cable that, when burned produces far less toxic smoke than ordinary electric cable.

Further, it is an object of the present invention to disclose a unique mixture which has improved characteristics over prior art silicone mixtures.

SUMMARY OF THE INVENTION

The present invention discloses an improved electric cable, and a method for making same, that will produce far less toxic fumes when burned and has better survivability when exposed to fire.

More particularly, a cable according to the present invention is formed by wrapping a glass fiber yarn, such as Fiberglas™ yarn around the outer periphery of an electrical conductor. The electrical conductor is sent to a wrapping section where it is wrapped with the yarn and then travels to an impregnating section. The glass fiber yarn is impregnated with a first silicone compound at this impregnating section. The impregnation is controlled so that it does not extend to the inner periphery of the glass fiber yarn, but will saturate the outer periphery of the yarn wrap. From the impregnating section, the wrapped wire goes into a drying section where the compound is dried within the yarn. The wire then travels to a second coating section where an additional silicone compound is coated upon the outer periphery of the yarn. The wire then enters a second drying section and is then coiled upon a reel for distribution.

The electric conductor that is wrapped with the yarn may be a bare electric wire, or it may be an individually insulated group of wires; that is, it may be wrapped around a plurality of individual electric wires to form a multi-strand

-3-

cable. In the multi-strand cable, each individual wire may constitute a wire made according to the process of this invention.

In a most preferred embodiment of the present invention, the glass fiber yarn is a no-resin or low-resin type glass fiber yarn which has no or little synthetic resin in combination with glass fibers, but instead uses a starch/oil binder. It is believed that the percentage of the binder in the most preferred yarn is also low compared to other similar yarns. Synthetic resins which may be used to make glass fiber yarn could create a smoke more harmful than a smoke from the silicone mixtures which are used as impregnating mixtures in this invention. In a sense, the impregnating first silicone mixture is substituted for a percentage of the synthetic resin that would otherwise be in the glass fiber yarn. The resulting cable will produce a far less toxic smoke than ordinary electric cable in which a glass fiber yarn may have a high synthetic resin content.

The silicone mixtures utilized as coatings in this invention include various silicone rubbers that are mixed with both clay and alumina trihydrate. In a most preferred embodiment of the present invention, the clay is a refractory clay that has good heat resistant characteristics. These types of clays have typically be utilized in brick making. The resulting silicone mixtures include both alumina trihydrate and the clay, and have a number of applications in forming various articles, including floor tile. Thus, the mixtures themselves are important features of this invention.

Further objects and features of the present invention can be best understood upon reading the attaching specification and drawings, of which the following is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-section through a single strand cable as disclosed by the present invention.

Figure 2 is a cross-section through a multi-strand cable as disclosed by the present invention.

Figure 3 is a flowchart showing the process used to create the improved electric cable of the present invention.

Figure 4 illustrates an embodiment of machinery that may be used to create the improved cable of the present invention.

Figure 5 is an enlarged section of a portion of the machine illustrated in Figure 4.

Figure 6 is a cross-section taken along line 6-6 of Figure 5.

Figure 7 is an enlarged portion of the machine illustrated in Figure 4 showing the coating section.

Figure 8 is an alternative embodiment for the coating section of the machine illustrated in Figure 4.

Figure 9 is an alternative embodiment for the wrapping section of the machine illustrated in Figure 4.

Figure 10 is a cross-section of the alternative embodiment of the wrapping section illustrated in Figure 9.

-5-

Figure 11 is an alternative embodiment of the electric cable illustrated in Figure 2.

Figure 12 is a flowchart of the process that will be utilized to create the alternative embodiment of electric cable illustrated in Figure 11.

Figure 13 illustrates an alternative embodiment of the coating section illustrated in Figure 7.

**DETAILED DESCRIPTION OF
THE PREFERRED EMBODIMENT**

The main features of the improved electric cable of the present invention can be best understood upon review of Figures 1 and 2.

Figure 1 illustrates a cross-section through an electric cable according to the present invention that insulates a single electric conductor. The improved single strand electric cable 20 has a central bare electric wire conductor 22 that is surrounded by glass fiber yarn wraps 24. It is to be understood that the wrap is illustrated in a simplified way. The actual wrap may be of a different configuration and may have several layers. A portion 26 of these wraps that is in contact with electric conductor 22 remains unimpregnated, while an outer portion 28 of wrap 24 is impregnated by a first silicone compound. An outer coating 30 of a second silicone compound is disposed around the glass fiber yarn wrap 24. Fiberglas™ yarn may be utilized as the glass fiber yarn for the wrap. One suitable yarn is available from PPG Industries under the code PPG G-75-190-0.75 656. This yarn uses a starch/oil size binder for the glass fibers. It is believed that the percentage binder is low compared with other glass fiber yarns.

-6-

Figure 2 illustrates the improved multi-strand electric cable 32 according to the present invention. Multi-strand cable is also known as wire-for-plenum. A plurality of insulated single wires 34 are disposed at a central portion of the improved multi-strand cable 32 and may each individually be single strand cables according to the improved electric cable illustrated at 20 in Figure 1. That is, this improved multi-strand cable 32 may be wrapped around single electric wires such as illustrated at 20, or it may be wrapped around ordinary prior art insulated wires. The improved multi-strand cable 32 comprises wraps 24 wrapped around the outer periphery of the multiple single insulated wires 34. The wrap 24 has nonimpregnated section 26 and impregnated section 28 and outer coating 30 similar to the single strand embodiment 20.

The exact composition of the various silicone compounds, compositions or mixtures will be described below. The electric cables illustrated in Figures 1 and 2 combines the best characteristics of a glass fiber yarn wrap that is resilient and tough and the silicone coating that will provide some flexibility and some unity to the cable. Without the coating compound the glass fiber wrap may fray and may not be adequate for use in an electric cable application. Without a wrap, the silicone compound would not be tough and resistant to abrasion. The overall combination of the glass fiber yarn and silicone compound results in an insulation for an electric cable that will create a much less toxic smoke if burned. Also, if the insulation is exposed to fire, it has a much higher burning point than the standard electric cable commonly available today. In addition, if the insulation is exposed to fire and is raised beyond its burning point, the insulation is less likely to melt and short circuit the electric cable. When insulation such as is illustrated in Figures 1 and 2 is exposed to heat beyond its burning point the silicone compound and glass fiber yarn will usually leave an ash about the electric cable that

-7-

will still provide insulation and will prevent short circuiting. This will allow the electric cable to continue to be utilized unless it is physically contacted. That is, if something happens to bump into the cable the ash will fall away and the wire may then short circuit. This is an important feature since these electric cables may be utilized as control wires for controlling such features as a fire alarm, a sprinkler system or in aircraft. Obviously, it is important that the control wires for such systems have as much burn survivability as possible. Prior art electric cable coatings such as PVC and Teflon when burned, melt and fall away thus allowing an electrical system to short circuit.

Figure 3 shows a flowchart of a process for creating an electric cable as illustrated in Figures 1 or 2. Flowchart 36 illustrates a roll of wire 38 that may be a single electric conductor 22 or may have a group of electric conductors such as illustrated in Figure 2 as numeral 34. That is, the roll 38 may dispense a single bare electric conductor 22, or may dispense a group of plural insulated electric conductors 34. Alternatively, a series of rolls 38 may each dispense a single insulated electric conductor 34 and the entire series may result in the plural cables 34 for the multi-strand electric cable as illustrated in Figure 2. From the roll 38, the conductors go into a wrapping section 40 where a glass fiber wrap is disposed around their outer periphery. An impregnating section 42 has a motor that pulls the wire through the wrapping section. At the impregnating section 42, a first silicone compound is impregnated into the yarn that has been previously wrapped about the electric conductor. It may be preferable in some instances to have a pulling section pulling the wire intermediate the wrapping and impregnating sections rather than having the impregnating section solely doing the pulling. From the impregnating section, the wire then travels into a drying section 44 where the silicone compound that has been impregnated

-8-

into the wrap 24 is dried. As the wire leaves the drying section 44 it enters a coating section 46 where a second silicone compound is coated about the outer periphery of the impregnated wrap. The wire leaves this coating section 46 and then enters a second drying section 48 where the silicone coating is again dried. From drying section 48 the wire enters a coiling section 50 where it is placed back on coils for distribution. A control 52 controls the various motors and pumps that will be necessary to move the wire and insert the silicone compounds to the various sections.

A machine for accomplishing the process shown in Figure 3 is illustrated in Figure 4. As shown in Figure 4, wire roll 38 is a standard roll rotatably mounted upon a fixed body or support. A motor 54 is shown as driving the motors associated with the wrapping section 40 and the impregnating section 42. Motor 54 drives a belt 56 that drives a driven element 58. Motor 54 also drives a second belt 60 that drives a second driven element 62 that in turn drives a flexible transmission 64 to drive a driven disc 66 in the impregnating section 42. Wire leaves wire roll 38 at 68 and enters wrapping section 40. Wire 68 with a single wrap of yarn is illustrated at 70 and this continues on through the wrapping section 40 to a second yarn wrapping station. Twice wrapped wire is illustrated at 72. Wire leaves the wrapping section 40 and at 74 enters the impregnating section 42. Wire 76 then leaves the impregnating section 42 and continues on to the drying section 44 and therethrough at 78 enters into coating section 46. Wire leaves coating section 46 and at 80 is seen to enter the second drying section 48. The wire leaves the second drying section 48 at 82 and is then coiled on wire coil 50.

A fixed stand or support 84 mounts the wire roll 38, the motor 52 and the driven element 58. A carriage 86, that is part of wrapping section 40 is rotatably mounted upon stand 84.

-9-

Carriage 86 comprises three plates, a first end plate 88, a central plate 90 and a second end plate 92. Bars 94 connect end plate 88 and central plate 90 and central plate 90 and second end plate 92. Guide elements 96 are mounted on both faces of central plate 90, one facing each of the end plates 88, 92. A first group of spools of glass fiber yarn that are wound along a first direction are illustrated at 98 and a second group of spools of glass fiber yarn that are wrapped in the opposed direction are illustrated at 100. Eyelets 102 extend from guide elements 96 and are each associated with an individual spool of yarn 98, 100.

As can best be seen from Figure 5, yarn leaves spool 98 at a mid-point thereof and is guided through eyelet 102. The yarn is illustrated at 103 as being wrapped upon wire 70 in a first orientation. Spool 100 has yarn wrapped upon it in an opposed direction and this yarn is shown as leaving spool 100 and being guided through eyelet 102. The yarn is illustrated at 104 as being wrapped around wire 72. It is to be understood that the opposed orientation of spool elements 98 and 100 result in a first wrapping of yarn that surrounds the wire 70 in a first orientation and a second wrap of yarn around this first wrap in a second orientation. The first orientation may be for instance, clockwise while the second orientation may be counter clockwise.

The wire is pulled through the wrapping section 40 by the impregnating section 42. As the wire is pulled through the wrapping section, the wrapping section carriage 86 is driven by driven element 58. As carriage 86 rotates, plates 88, 90, 92, bars 94, spools 98 and 100, guide elements 96 and eyelets 102 all rotate as a unit. The relative speed of rotation of carriage 86 and the pulling speed of the wire is selected to ensure an adequate wrap of glass fiber yarn about the wire. Driven element 58 and plates 88, 90 and 92 each have a central

-10-

bore that allows the wire 68, 70, 72 to pass therethrough. The bore in central plate 90 is illustrated at 105 in Figure 5. Thus, the wire is not rotated with the carriage 86 but is pulled along through the wrapping section 40 by impregnating section 42. As the wire is pulled through the wrapping section 40, the carriage 86 is driven by driven element 58 and yarn is wrapped around wire 70 in a first orientation at 103 and then downstream in a second orientation at 104. The wire thus leaves the wrapping section at 74 with a yarn wrap about its outer periphery.

For multi-strand cable the strands may be initially tied together to begin the wrapping of the strands. The glass fiber yarn is glued to the wire to begin the wrapping process.

As illustrated in Figure 6, central plate 90 has bars 94 extending from it towards the second end plate 92 and a guide element 96 fixed to a central portion thereof. Spools 100 can be seen as being mounted at four circumferentially spaced positions on central plate 90 and eyelets 102 can be seen as being associated with each of spools 100 and being fixed to guide element 96. As can be seen, the wire 74 extends through core 105 and is wrapped at 104 with the four strands of glass fiber yarn.

Returning now to Figure 4, the impregnating section will be further explained. As described above, the impregnating section 104 consists of a first driven disc 66 that is driven by motor 54. Second disc 106 and third disc 108 are idler discs and are mounted parallel to driven disc 66 on each side thereof. Discs 66, 106 and 108 are each formed with an outer rim 109 that has a groove at its outer periphery to receive the wrapped wire 74. A tank 110 is mounted below the discs 66, 106, 108 and contains a bath 112 of a first silicone compound. The level of silicone compound 112 is preferably kept below the

-11-

lower most extent of the discs 66, 106, 108. Pump 114 is mounted below tank 110 and is connected to silicone bath 112 by an inlet 116. Pump outlet 118 leads from pump 114 to an injector 120 that may be a small needle, such as a hyperdermic needle.

As wire 74 is pulled by driven disc 66 over idler discs 106 and 108, pump 114 sends silicone compound from bath 112 through outlet 118 to injector 120 and the silicone compound is injected onto the glass fiber yarn. It is preferred that only enough compound is injected onto the yarn so as to impregnate a portion of the outer periphery thereof. The compound is prevented from entering the inner periphery of the yarn since this would create an insulation that would be difficult to strip away from the electric conductor. Wire 74 with a wrap that has been impregnated by silicone compound at its outer periphery is then squeezed between discs 66 and 106 in grooves 109. Wire 74 then travels about the lower outer periphery of driven disc 66 and is squeezed between disc 66 and 108 again in grooves 109.

The squeezing by the discs impregnates the yarn. It is not necessary to accurately meter the compound since any excess would merely fall back into bath 112. It is preferred that only three discs be utilized since a greater number could result in the impregnation going too deep.

The wrapped impregnated wire then leaves impregnating section 42 at 76 and is pulled into a drying section 44 by rollers 124. Drying section 44 has an outer housing 122 and opposed silicone rollers 124. It is preferred that silicone compounds are used to create rollers 124 since the drying section 44 will be at a high temperature and silicone has

-12-

resistance to these high temperatures. Within drying section 44 are two conventional heat lamps 126 and 128. Other types of drying elements may be utilized.

The wrapped, impregnated, dried cable then leaves drying section 44 at 78 and enters a second coating section 46.

A first embodiment of a coating section will now be described with reference to Figure 7. The second coating section 46 has outer housing 130 and receives a second silicone compound through a first port 132. This second silicone compound is preferably inserted into the housing 130 at a pressure of approximately 40 psi. The compound enters into a chamber 136 where it is allowed to circulate about the electric cable 78 and then leaves through a second port 134. It is important to maintain the circulation of the silicone compound to prevent set-up of the compound. Electric cable 78 is still at a raised temperature since it was recently in drying section 44 and the heated cable attracts the silicone compound to ensure a good outer coating. In an example, the wire was maintained at 450-500° F. and the silicone compound at 0° F. This also helps prevent the compound from setting up. These temperatures are applicable to all the coating section embodiments. It may be preferable to include an additional heating section between drying section 44 and coating section 46 to ensure that cable 78 is at a desired temperature. It is to be understood that control valves are placed in lines 132, 134 to control flow therethrough.

Figure 7 illustrates a coating section that is preferably used when making multi-strand cable 32. Coating housing 130 consists of a main portion 138 that receives a plug member 139. The use of a plug, such as member 139 allows easy access into housing 130 for cleaning or the like.

-13-

The wrapped, impregnated, dried, coated wire leaves second coating section 46 at 80 and enters a second drying section 48 that is identical to first drying section 44. The wire leaves this second drying section 48 at 82 and is wound on coil 50.

The second embodiment of the second coating section 46 is illustrated in Figure 8. This embodiment is preferably used when making single strand cable 20. This coating section 140 has a coating inlet 142 and a coating outlet 144. A line 146 leads to a vacuum pump. Coating section 140 is preferably mounted extending vertically upwardly. That is, when using coating section 140 it is preferable that the wire leaving drying section 44 is turned directly vertically upwardly into coating section 140. Thus, as illustrated, coating section 140 has coating outlet 144 at a lower most vertical position, coating inlet 142 at an intermediate vertical position and a line to vacuum 146 at an uppermost vertical position. Wire 78 can be seen to be entering modified coating section 140 at 78 and leaves modified coating section 140 at 80. When using this modified coating section, the rest of the flow chart 36 and apparatus is identical to that shown in Figures 3 and 4. It is envisioned that a third silicone compound may be preferably used when using coating section 140.

Coating section 140 is especially preferred for use in coating a single strand of electric wires such as illustrated in Figure 1. When using coating section 140, a coating enters 142 into chamber 148 where it contacts the electric cable 78. Electric cable 78 is coated and the coating leaves through port 144. While the coating operation is in effect, vacuum line 146 is closed. When coating is interrupted, vacuum 146 is initiated and inlet 142 and outlet 144 are closed. The opening and closing of the lines is controlled by control valves (not shown) that are mounted in lines 142, 144, and 146. This combination

-14-

prevents the coating from being exposed to any particular portion of wire for an overly long period of time. That is, if the cable 78 were left in coating section 140 for a period of time while the line is stopped, coating may build up on that particular section of cable and that would be undesirable. With the use of vacuum 146, no leakage coating will be allowed in chamber 148 while the line is stopped.

An alternative wrapping section 150 is illustrated in Figure 9. Alternative wrapping section 150 has a central plate 152 upon which are mounted spools 154. Cable 68 leaves wire roll 38 similar to wrapping section 40. Guide elements 96 are mounted on central plate 156 and eyelets 156 extend from guide elements 96. Yarn at 158 can be seen to leave the axial end of spool 154 and extend through a S-shaped tube 160. S-shaped tube 160 causes the yarn 158 to go through a tortious series of turns that ensures adequate tension. Yarn at 162 leaves S-shaped tube 160 and is wrapped upon wire 68 similar to wrapping section 44. S-shaped tube 160 may be a clear plastic tube or the like.

Figure 10 illustrates first end plate 164 of alternative wrap section 150. As can be seen there are twelve spools 154 illustrated in alternative wrap section 150. Spools 154 may be arranged at the same radial extent, as illustrated in Figure 10, or they may be staggered at various radial positions. In alternative wrap section 150, as illustrated in Figures 9 and 10, only a single wrap of glass fiber yarn is applied to cable 68. It is envisioned that a second opposed wrap may also be utilized with alternative wrap section 150, similar to the arrangement used in wrap section 40. However, it may be preferable that only a single wrap be placed upon the electric cable 68.

-15-

A no, or low synthetic resin glass fiber yarn is most preferably utilized in the above-described cables. When such a glass fiber yarn is utilized, the glass fibers will be able to "absorb" a greater amount of the silicone mixture. The impregnating silicone mixture will produce a much less harmful smoke when burned than some of the prior art synthetic resin compounds that may have been utilized. For this reason, it is an important object of this invention that a no, or low synthetic resin glass fiber yarn be utilized.

A third type of electric cable 166 is illustrated in Figure 11. Cable 166 consists of a series of electric conductors 168 similar to that illustrated in Figure 2, however, rather than using a glass fiber yarn wrap a silicone tape 170 is wrapped about conductors 168. This silicone tape is formed from a silicone compound such as is associated with the various impregnating or coating sections and is made by commonly known processes. An outer coating 172 is placed about silicone tape 170 similar to the coating 46 utilized with the other types of wire.

With reference to Figure 12, a flowchart for producing this third embodiment of wire will be explained. Wire roll 176 contains wire similar to wire roll 38 in the first embodiment. A tape wrapping section 178 contains a tape wrapping machine that wraps the silicone tape around the several electric conductors. Tape wrapping machines are well known for wrapping tape about electric conductors, however, they have not been used with silicone tape. From tape wrapping section 178 the wire goes to coating section 180 that is similar to either of the two coating sections previously described, or, the third coating section described below. The coated cable then enters drying section 182, again similar to previously described drying sections. From drying section 182 the cable goes to coiling

-16-

section 184 similar to the previously described coiling section. Control 186 controls the various sections of this process.

A third embodiment of the coating section can be seen in Figure 13. This coating section 188 is preferably used with a multi-strand cable such as illustrated in Figure 2. Coating section 188 consists of a first coating portion 190, an intermediate cooling portion 192 and a second coating portion 194. First coating portion 190 consists of chamber 196 that surrounds the electric cable and an inlet 198 that receives pressurized silicone compound into chamber 196. The compound is circulated within chamber 196 to prevent it from setting up, and eventually exits through exit 200.

The intermediate cooling section 192 consists of a chamber 202 that surrounds the cable and an inlet 204 that supplies cooling fluid to chamber 202. In a preferred embodiment of this invention, this cooling fluid may consist of water with an additive that has good thermal transfer characteristics, as an example ordinary anti-freeze may be utilized. The cooling fluid circulates through chamber 202 and exits through port 206.

Second coating portion 194 has chamber 208 again surrounding the cable and port 210 supplies the silicone compound to the chamber 208. The fluid circulates within chamber 208 and exits through port 212.

The wire at 78 enters coating portion 188 through port 213 and is coated within chamber 196. As the wire leaves chamber 196 it goes through guide port 214 separating first coating portion 190 from cooling portion 192. The size of the orifice at guide opening 214 is chosen to be slightly larger than the orifice at opening 213 to accommodate the extra

-17-

diameter of the wire due to the coating. As an example, it may be .015 inches larger in diameter. Wire leaves cooling chamber 202 through guide opening 216 and enters second coating portion 194. The cable is coated in second coating portion 194 and exits through guide opening 218 at 80. Guide opening 218 is chosen to be slightly larger in diameter than opening 214 or 216, again to accommodate the extra diameter that the wire will now have due to the coating that has been applied in second coating portion 194. The cable at 80 is pulled through the coating section 188 by a force of approximately 150 foot pounds of tension. It is necessary to apply such a large force to pull the wire through coating section 188 since the guide openings 213, 214, 216 and 218 must be approximately the same diameter as the wire to ensure good sealing between chamber 190, 192 and 194. In a preferred embodiment, the rollers 124 in drying section 48 will provide the tension to pull the cable through the coating section 188. Lines 198, 200, 204, 206, 210 and 212 may all be provided with control valves.

The various silicone compounds utilized with the processes will now be described.

A first compound is envisioned for use with the impregnating section and consists of a silicone compound diluted with a thinner. For the silicone compound, any type of high voltage insulator coating that is silicone based may be utilized. Preferably, a vulcanizing silicone rubber is utilized. Most preferably, an amine or oxime cure room temperature vulcanizing silicone rubber with at least 50%, and up to a maximum of 58%, of aluminum trihydrate for fire retardancy. As an example, Sylgard™, available from Dow Corning, Midland, Michigan, may be utilized. For the thinner, an industrial solvent such as inhibited 1,1,1, trichloroethylene is desirable.

-18-

An example of this compound was produced by mixing 80 percent by volume of the silicone compound high voltage insulator coating and 20 percent by volume of the thinner, the trichloroethylene.

A second compound that is envisioned for use with the coating sections, in particular, the first and third embodiment of the coating section, consists of a silicone compound that is mixed with clay and alumina trihydrate. These two additives add flexibility and resiliency to the silicone compound. The silicone compound utilized with this second compound may be any type of silicone compound that has good characteristics as an electric insulator. Preferably, a liquid silicone rubber is utilized. An example may be Silastic™, available from Dow Chemical Corning. This product consists of two compounds that are combined to initiate the setting up or curing of the product. The product is described in U.S. Patent No. 3,445,420 entitled "Acetylenic Inhibited Platinum Catalyzed Organopolysiloxane Composition" issued to Kookootsedes, et al. The clay is dried, pulverized and sifted until very fine.

A particular clay that was utilized to make the below disclosed examples of this compound consisted of 20 to 30 percent of illite, 10 to 15 percent of vermiculite, 10 to 15 percent of kaolinite, 10 to 15 percent of quartz, less than 5 percent of feldspars, 5 to 10 percent of calcite and 10 to 15 percent of dolomite. These are volume percentages from the dried material and not the original moist clay.

The above-described clay is a refractory clay which has good heat resistant characteristics. This type of clay has been utilized in the past in forming bricks which are to be exposed to fire or other sources of high heat.

-19-

In addition, the following densities of materials were used for the below disclosed examples. The clay weighed 1.24 pounds per pint. The Silastic™ compound weighed 1.84 pounds per pint. The Sylgard™ compound weighed 1.26 pounds per pint.

An example of this compound was produced by mixing 60 percent by volume of the Silastic™ compound, 30 percent by volume of the dry sifted clay and 10 percent by volume of the alumina trihydrate.

The clay, the alumina trihydrate and the two compounds that make up the Silastic™ compound were mixed and stored in a container that was maintained at 0° F. for at least twenty-four hours. A vacuum was applied to the container to remove air bubbles. The compound was then ready for use.

A third compound is envisioned for use with the coating, in particular for the alternative coating illustrated at Figure 8. This third coating consists of a silicone compound, clay and alumina trihydrate. It is envisioned that the same silicone coating utilized with the first compound may be utilized with this third compound. The clay and alumina trihydrate are similar to that used with the second compound.

An example of this third compound was produced by mixing 80 percent by volume of the Sylgard™ compound, 15 percent by volume of the dry sifted clay and 5 percent by volume of the alumina trihydrate.

The clay and alumina trihydrate were initially mixed. A small percentage of the Sylgard™ compound was stirred into the powders to create a paste. The remainder of the Sylgard™ compound was then stirred into the mixture. The

-20-

compound may be exposed to some means for maintaining circulation while it is stored but preventing it from settling-up.

The tape and dryer rollers are preferably formed from a product similar to Silastic™.

An example of this third compound was produced by mixing 80 percent by volume of the silicone compound, 15 percent by volume of the dry sifted clay and 5 percent by volume of the alumina trihydrate.

A working embodiment of the present invention has been disclosed, however, certain modifications of the invention would be envisioned by one of ordinary skill in the art. The intended scope of the present invention can be best understood from the appended claims.

-21-

CLAIMS

1. A method of producing electric cable comprising the steps of:
creating a cable by;
wrapping a glass fiber yarn around a bare electric conductor; and
impregnating the yarn with a first material.
2. A method as recited in claim 1, and wherein there is a second coating step in which a material is coated around the impregnated yarn.
3. A method as recited in claim 2, and wherein there are additional method steps in which the cable is sent through a drying chamber after the impregnating step and after the coating step.
4. A method as recited in claim 3, and wherein the cable is ran serially through a wrapping section, an impregnating section, a drying section, a coating section and a second drying section, the cable being pulled directly vertically upwardly through the coating section.
5. A method as recited in claim 1, and wherein said first and second materials used in the impregnating and coating steps are silicone based compounds.
6. A method as recited in claim 1, and wherein the wrapping of yarn includes a wrap in a first direction and a second wrap in an opposed direction.

-22-

7. A method for insulating electric wire comprising the steps of:

- (a) wrapping a wrap material about the electric wire;
- (b) impregnating the wrap material with a first compound;
- (c) disposing a second compound about the outer periphery of the impregnated wrap material; and
- (d) coiling the coated wire onto a reel for distribution.

8. A method as recited in claim 7, and wherein said wrapping step is accomplished with a rotating carriage, the rotating carriage having spools of the wrap material mounted thereon, the rotating carriage rotating with respect to the wire to be wrapped, the wire to be wrapped being pulled through said wrapping section while said wrapping section is being rotated, the relative rotation of the wrapping section with respect to the wire causing the wrap material to be wrapped about the outer periphery of the wire.

9. A method as recited in claim 8, and wherein the wrapping step comprises a first wrap step in which the wrap material is wrapped in a first orientation and a second wrap step in which the wrap material is wrapped in the opposed orientation.

10. A method as recited in claim 7, and wherein a glass fiber yarn is used as the wrap material.

-23-

11. A method as recited in claim 7, and wherein the impregnating step is accomplished with an impregnating section that comprises three rotating discs, each of the discs having a groove at its outer circumference, the wire leaving the wrapping section and entering the impregnating section, a first compound being deposited upon the wrap material, the wire with the first compound being deposited thereon then being guided into the groove of the first disc and being squeezed between the first and second disc, the wire then being squeezed between the second and third disc, the depositing of the first compound and the squeezing of the wire between the discs causing the compound to be impregnated into the wrap material such that it will saturate the outer periphery of the wrap material but will not extend to the inner periphery of the wrap material.

12. A method as recited in claim 7, and wherein the impregnating step is followed by a drying step, this drying step raising the temperature of the wire prior to its entering the coating step, and the coating step is also followed by a drying step.

13. A method as recited in claim 7, and wherein the coating step is accomplished with a coating member consisting of two coating chambers and an intermediate cooling chamber, the second compound being introduced into the first coating chamber at a pressure higher than atmospheric, the wire being coated by this second compound within the first coating chamber, the wire then entering the cooling chamber, a cooling fluid being circulated through the cooling chamber, the wire then entering the second coating chamber, the second compound being introduced into the second coating chamber at a pressure higher than atmospheric pressure, the wire being coated in this second chamber also.

-24-

14. A method as recited in claim 7, and wherein the coating step is accomplished with a coating member that consists of a single coating chamber, the wire extending directly vertically upwardly into the coating chamber and leaving the coating chamber directly vertically upwardly, the second compound being introduced into the coating chamber at a first elevation, the second compound leaving the coating chamber at a second elevation, the second elevation being vertically below the first elevation, and a vacuum being applied to the chamber at a third elevation vertically higher than the first or second elevation, the vacuum only being applied when the wire is not being ran through the coating chamber, the second compound inlet and outlet being closed when the vacuum is being applied.

15. A method as recited in claim 7, and wherein the second compound used in the coating step consists of a liquid silicone rubber mixed with clay and alumina trihydrate.

16. A method as recited in claim 15, and wherein the first compound used in the impregnating step is a vulcanizing silicone rubber.

17. An electric cable comprising:
at least one electric conductor; and
glass fiber yarn being wrapped around said electric conductor, said glass fiber yarn having an inner periphery that contacts said electric conductor.

18. An electric cable as recited in claim 17, and wherein said yarn is impregnated by a first silicone compound.

19. An electric cable as recited in claim 18, and wherein said first silicone compound is impregnated into the outer periphery of said yarn, but does not impregnate the inner periphery of said yarn that contacts said electric conductor.

20. An electric cable as recited in claim 19, and wherein a second silicone compound coating is disposed about the outer periphery of said yarn.

21. An electric cable as recited in claim 20, and wherein said first silicone compound coating is a distinct material from said second silicone compound.

22. An electric cable as recited in claim 21, and wherein said second silicone compound is a mixture of a silicone compound, clay and alumina trihydrate.

23. An electric cable as recited in claim 22, and wherein a second silicone compound coating is disposed about the outer periphery of said yarn.

24. An electric cable as recited in claim 23, and wherein said first silicone compound coating is a distinct material from said second silicone compound.

25. An electric cable as recited in claim 17, and wherein there is only one of said electric conductors.

26. An electric cable as recited in claim 17, and wherein there are several of said electric conductors, each having an individual insulation within said yarn wrap.

27. An electric cable as recited in claim 26, and wherein each of said individual insulations of said several electric conductors each comprise glass fiber yarn wrapped around said individual electric conductors, said yarn having an inner periphery that contacts said electric conductor, said yarn being impregnated by a first silicone compound, said first silicone compound being impregnated into the outer periphery of said yarn, but not impregnated into the inner periphery of said yarn, a second silicone compound coating disposed about the outer periphery of said yarn, said first silicone compound coating and said second silicone compound coating being of distinct materials.

28. An electric cable comprising:
at least one electrical conductor; and
an insulation material mounted about said electrical conductor, said insulation material comprising a compound consisting of a silicone compound, dry sifted clay, and alumina trihydrate.

29. An electric cable as recited in claim 28, and wherein there are several of said electrical conductors, each being surrounded by its own individual insulation.

30. An electric cable as recited in claim 29, and wherein said several electric conductors are surrounded by a wrap of a silicone tape, and an outer coating surrounding said silicone tape being formed of said silicone compound.

31. An electric cable as recited in claim 29, and wherein said glass fiber yarn is wrapped around said several electric conductors to maintain them together; and
an outer coating is disposed around said yarn, said outer coating being formed of said silicone compound.

-27-

32. An electric cable as recited in claim 31, and wherein said yarn has a second silicone compound impregnated into the outer periphery thereof, said second silicone compound being distinct from said first silicone compound, said second silicone compound being impregnated into the outer periphery of said yarn but not extending therethrough to the inner periphery thereof.

33. A multi-strand electric cable comprising:
a cable;
a plurality of individually insulated conductors at the center of said cable;
a glass fiber wrap about the circumference of said plurality;
said glass fiber wrap being impregnated by a first compound, said first compound comprising a silicone rubber; and
an outer coating about the circumference of said wrap, said outer coating comprising a silicone rubber.

34. A multi-strand cable as recited in claim 33, and wherein said second compound also comprises clay and alumina trihydrate.

35. A multi-strand cable as recited in claim 33, and wherein said glass fiber wrap is formed from Fiberglas[™] yarn.

36. A multi-strand cable as recited in claim 33, and wherein said glass fiber wrap consists of a first portion in a first orientation and a second portion wrapped in an opposed orientation.

-28-

37. An electric cable comprising:
at least one electric conductor; and
a glass fiber yarn wrapped around said electric conductor, said glass fiber yarn have no, or little synthetic resin and having an inner periphery that contacts said electric conductor, said glass fiber yarn being impregnated by a first silicone mixture.

38. An electric cable as recited in claim 37, wherein said glass fiber yarn having a starch/oil size as a binder in combination with glass fiber.

39. An electric cable as recited in claim 38, wherein said first silicone mixture is impregnated into the outer periphery of said glass fiber yarn, but does not impregnate the inner periphery of said glass fiber yarn, which contacts said electric conductor.

40. An electric cable as recited in claim 37, wherein a second silicone mixture coating is disposed about the outer periphery of said glass fiber yarn.

41. An electric cable as recited in claim 40, wherein said first silicone mixture is a distinct material from said second silicone mixture.

42. An electric cable as recited in claim 41, wherein said second silicone mixture is a mixture of a silicone compound, refractory clay and alumina trihydrate.

43. A silicone based mixture comprising:
a silicone rubber;
alumina trihydrate; and
clay.

-29-

44. A silicone based mixture as recited in claim 43, wherein said clay is a refractory clay.

45. A silicone based mixture as recited in claim 44, wherein said mixture is utilized to form a structural item, such as a tile.

46. A mixture comprising:
a silicone compound;
a clay material that has been dried, sifted and pulverized; and
alumina trihydrate.

47. A mixture as recited in claim 46, and wherein said silicone compound is a vulcanizing silicone rubber.

48. A mixture as recited in claim 47, and wherein said mixture consists of 80% by volume of said vulcanizing silicone rubber, 15% by volume of said dry sifted clay, and 5% by volume of said alumina trihydrate.

49. A mixture as recited in claim 48, and wherein said vulcanizing silicone rubber is Sylgard™.

50. A mixture as recited in claim 46, and wherein said silicone compound is a liquid silicone rubber.

51. A mixture as recited in claim 50, and wherein said mixture consists of 60% by volume of said liquid silicone rubber, 30% by volume of said dry sifted clay, and 10% by volume of said alumina trihydrate.

52. A mixture as recited in claim 51, and wherein said liquid silicone rubber is Silastic™.

53. A mixture as recited in claim 46, and wherein said mixture is utilized as an electrical insulator.

1/4

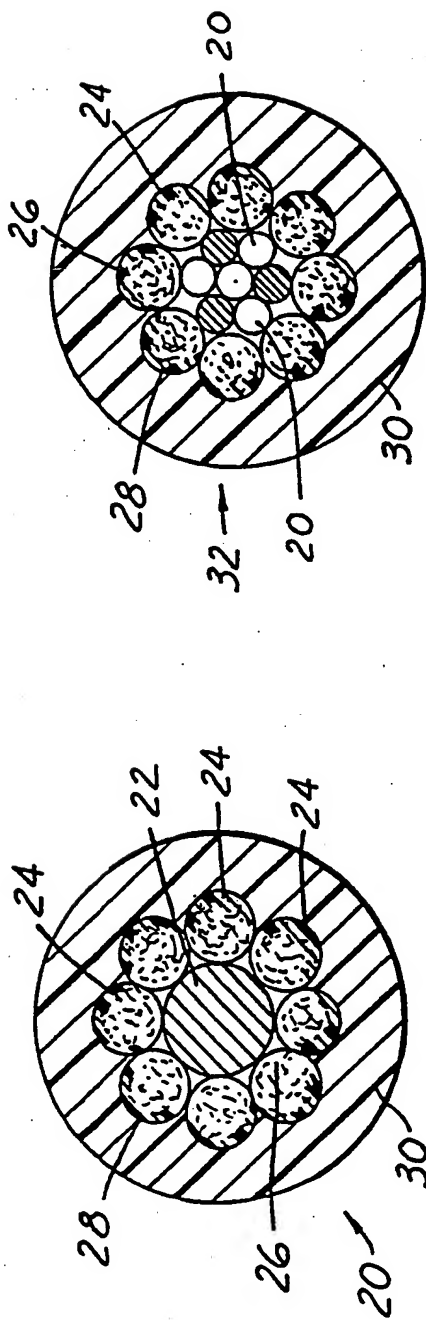


FIG. 1

FIG. 2

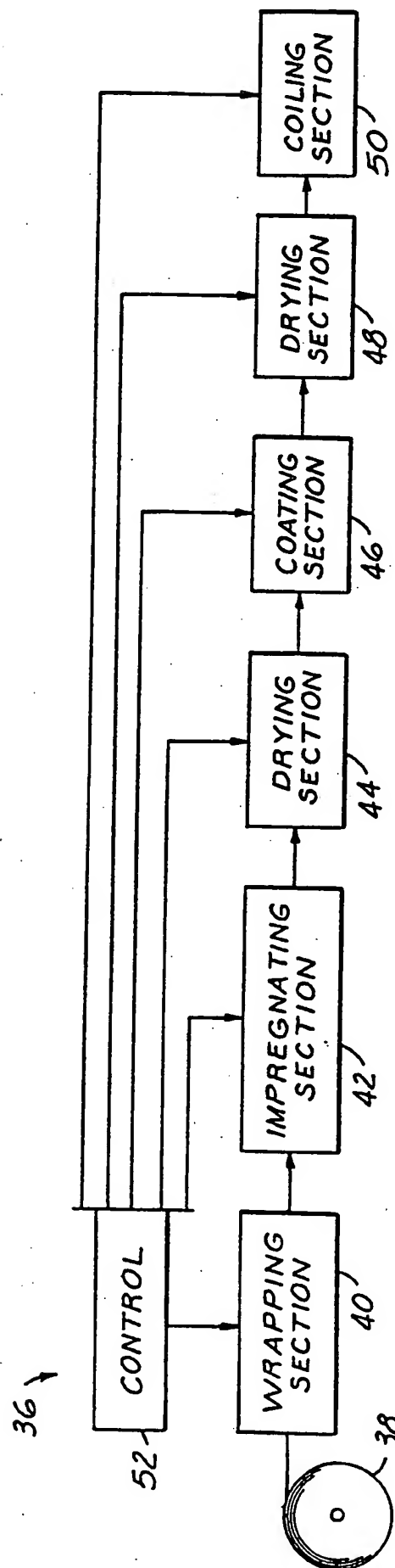


FIG. 3

2/4

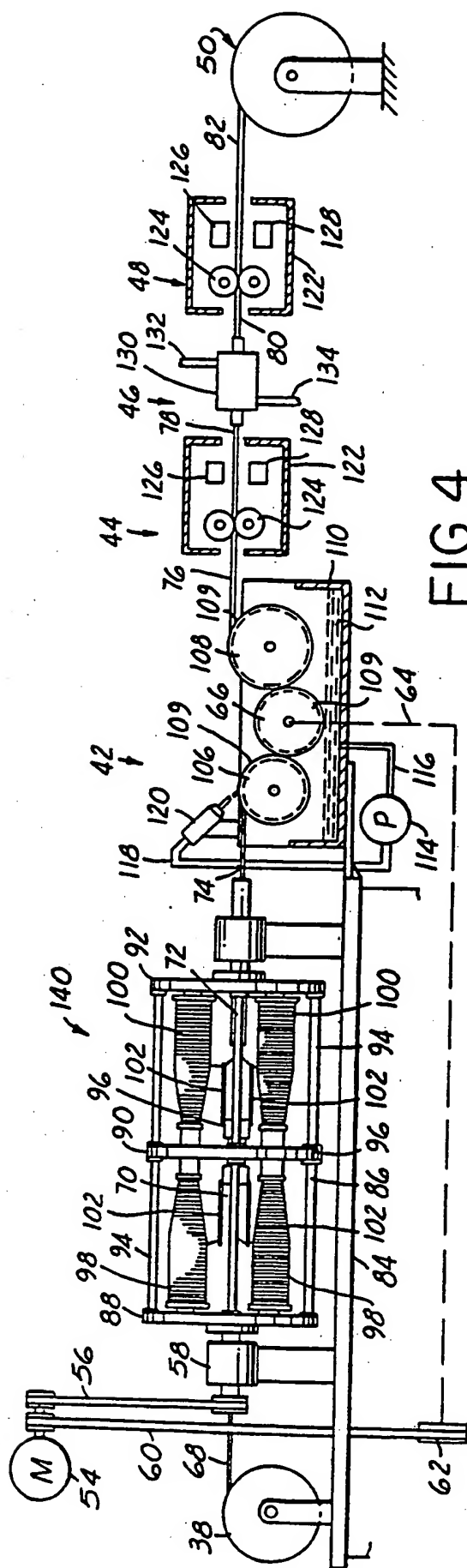


FIG. 4

SUBSTITUTE SHEET

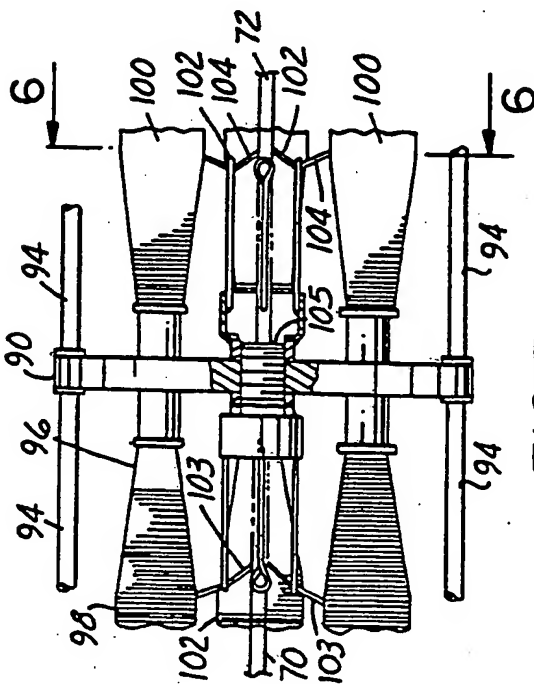


FIG. 5

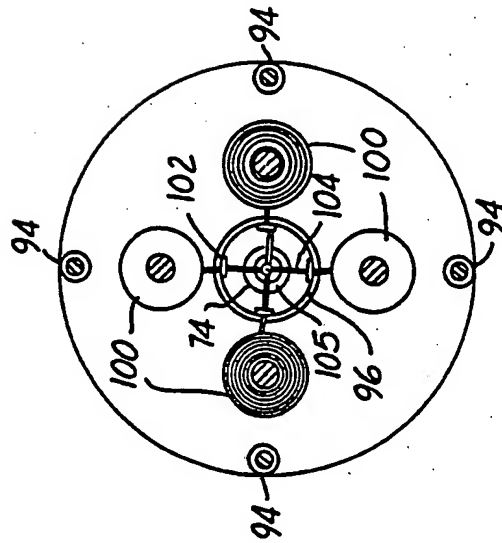


FIG. 6

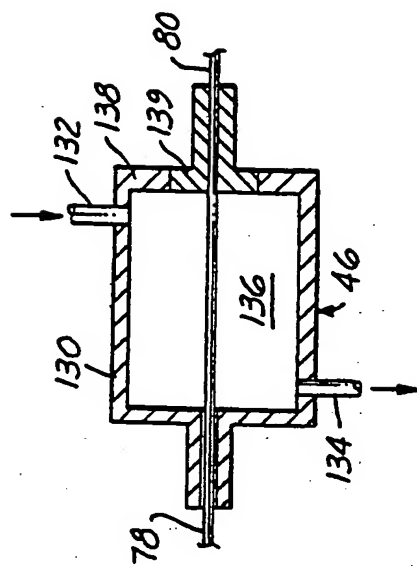


FIG. 7

3/4

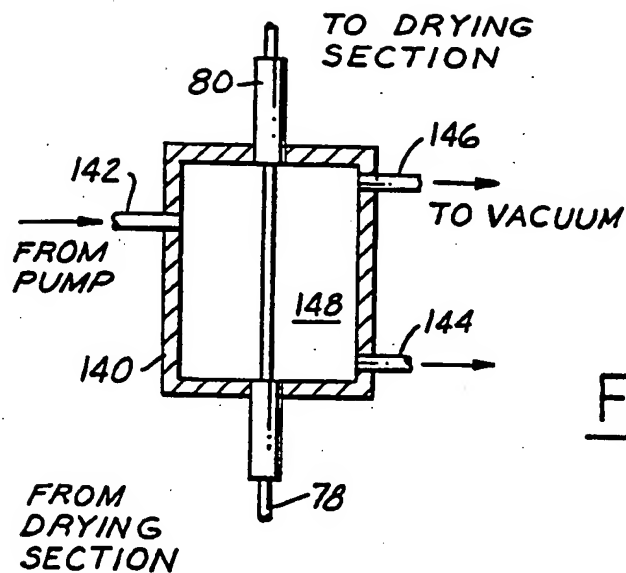


FIG. 8

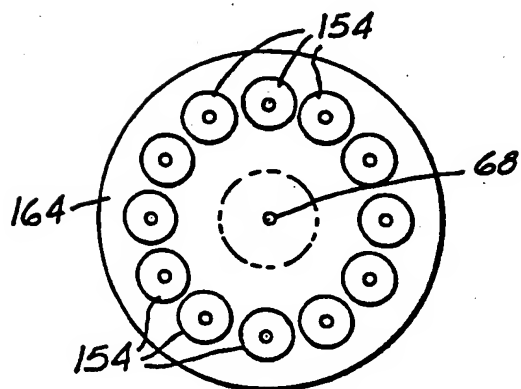


FIG. 10

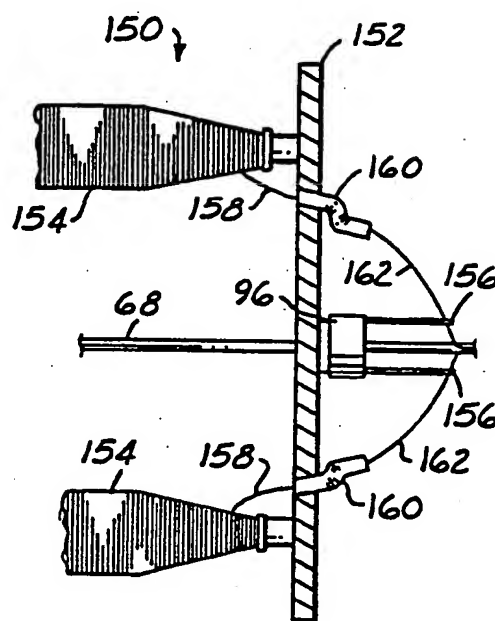


FIG. 9

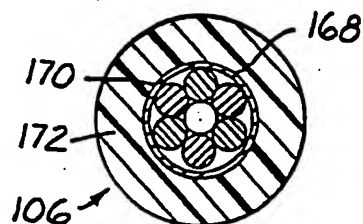
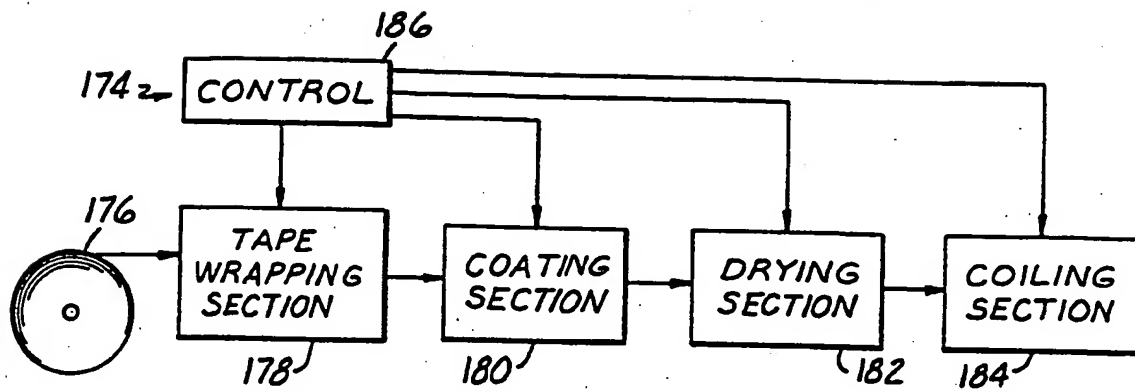
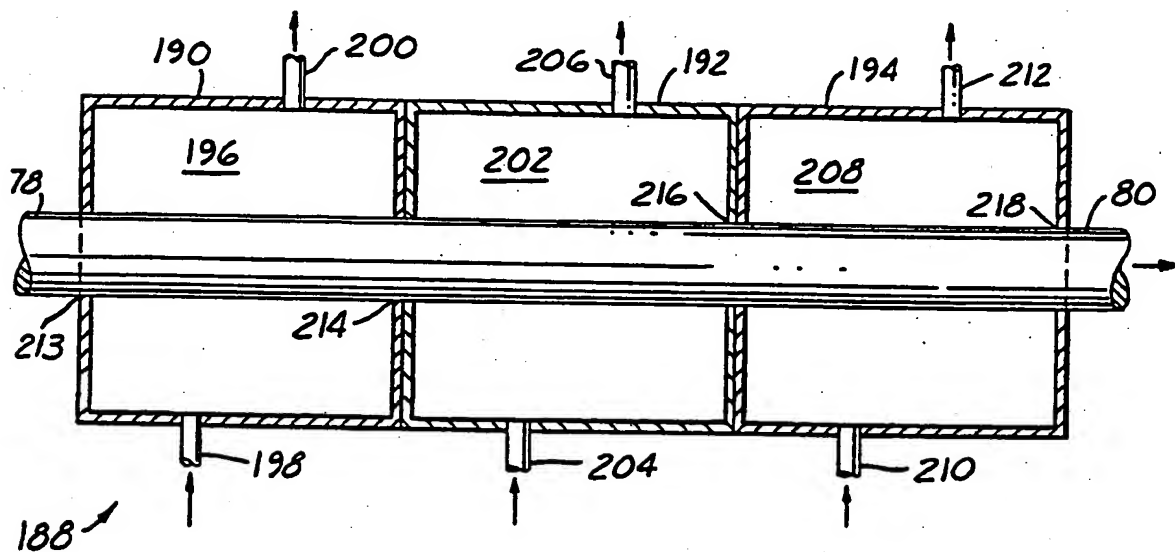


FIG. 11

4/4

FIG. 12FIG. 13

INTERNATIONAL SEARCH REPORT

International Application No **PCT/US90/01652**

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (5): **H01B 7/34, 13/06, 13/08**

U.S. CL: **174/121R, 110S, 121A, 121AR, 122E, 122G; 156/51, 53, 56, 80; 524/445**

II. FIELDS SEARCHED

Minimum Documentation Searched ⁴

Classification System |

Classification Symbols

U.S. **174/110S, 121R, 121A, 121AR, 122R, 122C, 122G, 124R
124G, 124GC; 156/51, 52, 53, 55, 56, 80;
524/445, 448**

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are included in the Fields Searched ⁵

III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴

Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁴
X, P	US, A, 4,910,361 (MUDGETT) 20 March 1990, See entire document	1-42
X, P	US, A, 4,906,308 (MUDGETT) 06 March 1990, See entire document	1-42
A	US, A, 4,514,466 (LEON, JR. et al) 30 April 1985, See entire document	
Y	US, A, 4,405,687 (MORITA et al) 20 September 1983, See entire document	15,16-36 and 42
Y	US, A, 4,388,127 (BRUNNER et al) 14 June 1983, See entire document	1-16
X Y	US, A, 4,202,812 (MURRAY) 13 May 1980, See entire document	43 and 44 46-53
Y	US, A, 4,051,324 (ANDERSON deceased et al) 27 September 1977, See entire document	1,2,17-19,25, 37 and 39
X Y	US, A, 4,011,168 (UHLMANN) 06 May 1974, See entire document	43 and 44 46,47,50 & 53
Y	US, A, 4,001,128 (PENNECK) 04 January 1977, See entire document	15,16-36 and 42
X Y	US, A, 3,576,940 (STONE et al) 04 May 1971, See entire document	1,2,17-21,33, and 37-41

⁶ Special categories of cited documents: ¹³

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search ¹

31 MAY 1990

Date of Mailing of this International Search Report ²

02 AUG 1990

International Searching Authority ¹

ISA/US

Signature of Authorized Officer ²⁰

Morris Nimmo
MORRIS NIMMO

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No ¹⁸
	continued from second sheet	
		15,16-36 and 42
Y	US, A, 3,445,420 (KOOKOOTSEDES et al) 20 May 1969, See entire document	45 and 49
A	US, A, 3,192,309 (ZODER et al) 29 June 1965, See entire document	
A	US, A, 2,993,949 (MOEBIUS et al) 25 July 1961, See entire document	
X	US, A, 2,983,700 (ROHM) 09 May 1961, See entire document	1,2 and 3-6 and 14-16
A	US, A, 2,795,640 (CRANDALL) 11 June 1957, See entire document	
X	US, A, 2,759,041 (COX) 14 August 1956, See entire document	1 and 6
Y	US, A, 2,639,247 (SQUIER) 19 May 1953, See entire document	1-7,10 and 14-16
X	US, A, 2,610,286 (COX) 09 September 1952, See entire document	1 and 6
X	US, A, 2,386,466 (HYDE) 09 October 1945, See entire document	1 and 5
X	US, A, 2,258,218 (ROCHOW) 07 October 1941, See entire document	1-3,5,17-19,25 37, and 39
A	US, A, 2,186,441 (YOUNG) 09 January 1940, See entire document	
A	JP, A, 52-35889 (SUMITOMO) 18 March 1977, See entire document	
A	AU, A, 156,607 (CALENDER'S) 20 May 1954, See entire document	
Y	GB, A, 520,246 (NAAMLLOOZE) 18 April 1940, See entire document	1,2,17-19,25, 37 and 39
A	GB, A, 555,354 (OKONITE) 18 August 1943, See entire document	
A	FR, A, 2,381,377 (DESCAZANX et al) 20 October 1978, See entire document	

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☒ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.